

# **Hands-On NetConf / SNMPv3 / CLI Demo Manual**

**with installation notes for Linux and Windows**

**NuDesign Technologies Inc.**

**2018**

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## DOCUMENT HISTORY

Date	Revision	Remarks
2013-05-25	1.0	Initial release
2013-11-04	1.1	Added CLI section
2014-04-01	1.2	Updated Demo section
2014-04-21	1.3	Document Revision
2015-04-04	1.4	Added notifications
04/16/2015	1.5	Minor updates to Sections 1 and 3
12/10/2015	1.6	Added Nacm
03/16/2016	1.7	Demo installation section update
08/08/2016	1.8	Addition of Linux based YANG Demo Agent
08/09/2016	1.9	Revisions to Linux documentation
08/11/2016	1.9.1	Fixes a list of supported Linux distributions on page 13
01/17/2017	1.10	Update for inclusion of implementation of ietf-interfaces. Minor updates to the Linux specific sections.
02/08/2017	1.11	Minor update relating to Linux installation.
12/10/2017	1.12	Document Revision
09/07/2018	1.13	Updates for Linux installation layout changes
09/17/2018	1.14	Correct subsystem executable name to ndncsub.

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# 1 Introduction

This document describes the NuDesign Multiprotocol DEMO agent (YANGDemoAgent). It is available for download from a NuDesign site at [www.ndt-inc.com](http://www.ndt-inc.com) as either a Linux or Windows installation package.

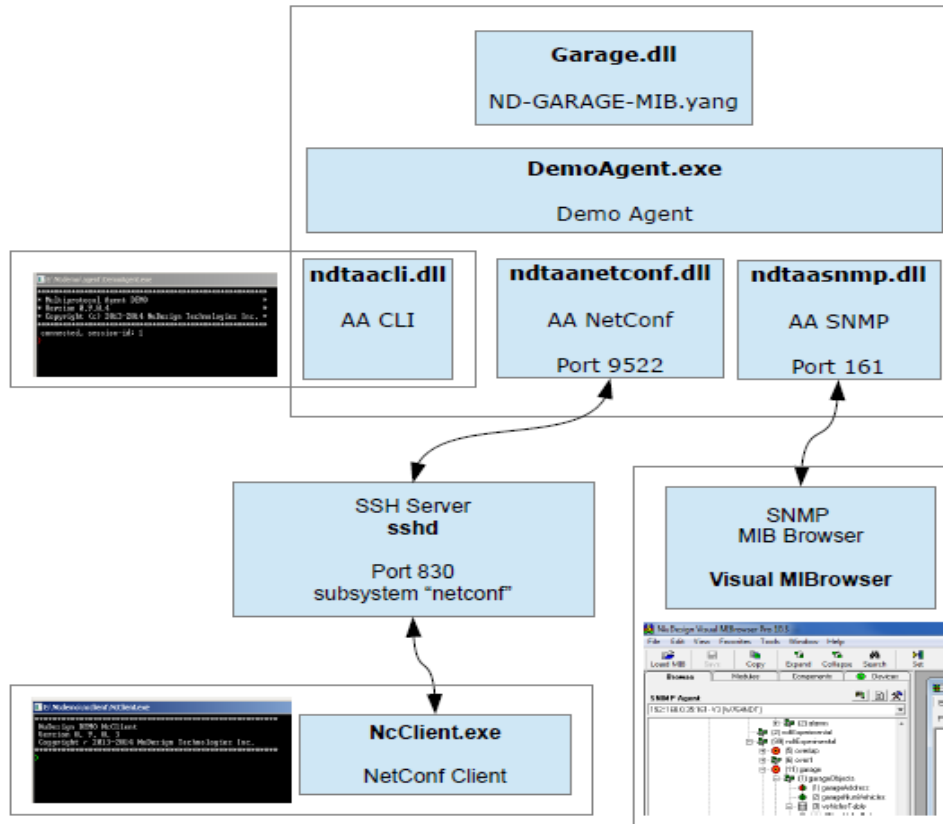
YANGDemoAgent implements data model defined in "ND-GARAGE-MIB" yang module along with a list of standard yang modules (see Files section for the complete list). "ND-GARAGE-MIB" yang-module is created by NuDesign Visual MIBBuilder (rev 5.2) from ND-GARAGE-MIB SNMP MIB Module. Both modules are listed in Appendix.

Access to the agent is provided via "AddOn Agent" (AA). AA is Dynamic-Link Library loaded by YANGDemoAgent at startup. It is protocol handler (NetConf/SNMP/...). Protocol operations that manipulate data (read/write) are commonly handled by data store in YANGDemoAgent, i.e. access to data is common irrespective of the protocol used to access it.

YANGDemoAgent is console application, AA CLI provides command line handling in the console.

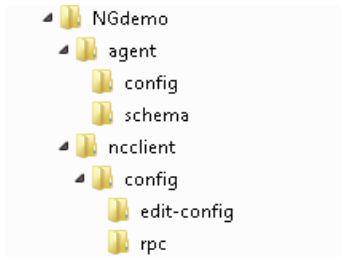
Before you start the YANGDemoAgent please stop any SNMP Agent you may have running on your computer, it would conflict with the Demo Agent that provides SNMP and NETConf access.

NcClient is NetConf client console application, it accesses YANGDemoAgent using NETCONF protocol over SSH. NuDesign Visual MIBBrowser is used as SNMP client.



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## 2 Windows Installation Files



### 2.1 ./agent

YANGDemoAgent.exe	demo agent
tinypath.dll	XML/Xpath library
ndtaacl.dll	CLI AddOn agent
ndtaanetconf.dll	NETCONF AddOn agent
ndtaasmp.dll	SNMP AddOn agent
Garage.dll	Implementation of ND-GARAGE-MIB yang module
ietfInterfaces.dll	Implementation of ietf-interfaces yang module

#### 2.1.1 ./agent/config folder

ngsettings.xml	configuration file for YANGDemoAgent
ngsettings_cli.xml	configuration file for CLI AddOn agent
startup-cfg.xml	startup configuration
m2y_*.xml	MIB-to-yang mapping files
mib_*.xml	MIB info files (generated by mib2xml tool)

#### 2.1.2 ./agent/schema folder

Repository of yang modules, `get-schema` rpc method looks here for yang files.

### 2.2 ./ncclient

NcClient.exe	NetConf client (command line)
libssh2.lib	SSH-2 api ( <a href="http://www.libssh2.org/">http://www.libssh2.org/</a> )

#### 2.2.1 ./ncclient/config folder

NcClient.xml	configuration file for NcClient
--------------	---------------------------------

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## 2.2.2 *.Incclient/config/edit-config folder*

Repository of files that contain portion of xml encoding of the `edit-config` rpc.

For example

```
> edit-config candidate 1
```

would generate the edit-config request for target=candidate, and the rest of the xml would be taken from file "1.xml" that resides in ...\\config\\edit-config folder. Content of these files should contain <default-operation>, <test-option>, <error-option> and/or <config> elements for valid edit-config request.

This is an example of the edit-config generated:

```
<rpc message-id="3" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <target>
      <candidate />
    </target>
    <default-operation>merge</default-operation>
    <test-option>set</test-option>
    <config>
      <interfaces xmlns:t="http://ndt-inc.com/ns/ndt-interfaces">
        <interface xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0" operation="create">
          <name>if6</name>
        </interface>
      </interfaces>
    </config>
  </edit-config>
</rpc>
```

Note that the red portion is directly copied from file "1.xml".

## 2.2.3 *.Incclient/config/rpc folder*

NcClient implements 'rpc' command. E.g.

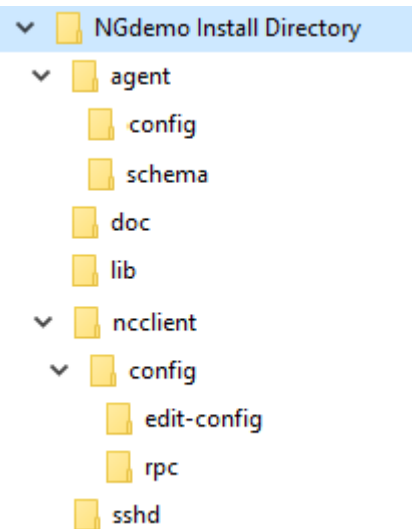
```
> rpc f1
```

This command would search for file "f1.xml" in "rpc" folder, and if found, read it and pass the content of this file to YANGDemoAgent for processing. An example of the content:

```
<rpc message-id="101" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get>
    <filter type="subtree">
      <garage></garage>
    </filter>
  </get>
</rpc>
```



### 3 Linux Installation Files



#### 3.1 ./agent

ndyangdemo	demo agent. Note this should be executed at <b>root</b> privilege level so that the included SNMP access agent can open UDP port 161.
demostart	Script to start the <b>ndyangdemo</b> , setting the environment variable <b>LD_LIBRARY_PATH</b> so <b>ndyangdemo</b> has access to libraries in <b>./lib</b> .

##### 3.1.1 ./agent/config folder

ndconf.xml	configuration file for YANGDemoAgent
ndconf_cli.xml	configuration file for CLI AddOn agent
startup-cfg.xml	startup configuration
Ndconf-err.xml	Configuration file for error messages
m2y_*.xml	MIB-to-yang mapping files
mib_*.xml	MIB info files (generated by mib2xml tool)

##### 3.1.2 ./agent/schema folder

Repository of yang modules, [get-schema](#) rpc method looks here for yang files.

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### 3.2 *./doc*

NuDesign YANG Demo Agent License Agreement.pdf	Licensing information.
Demo Quick Start.pdf	Demo usage documentation.
NuDesign ndCONF User Guide.pdf	NdCONF SDK user documentation.
Readme.txt	Release information.

### 3.3 *./lib*

Collection of libraries needed by the executables.

### 3.4 *./ncclient*

ncclient	NetConf client (command line)
ncclientstart	Script to invoke <b>ncclient</b> , setting the environment variable <b>LD_LIBRARY_PATH</b> so <b>ncclient</b> has access to libraries in.

#### 3.4.1 *./ncclient/config folder*

NcClient.xml	configuration file for NcClient
--------------	---------------------------------

#### 3.4.2 *./ncclient/config/edit-config folder*

Repository of files that contain portion of xml encoding of the **edit-config** rpc. For example

```
> edit-config candidate 1
```

would generate the edit-config request for target=candidate, and the rest of the xml would be taken from file "1.xml" that resides in ...\\config\\edit-config folder. Content of these files should contain <default-operation>, <test-option>, <error-option> and/or <config> elements for valid edit-config request.

This is an example of the edit-config generated:

```
<rpc message-id="3" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <target>
      <candidate />
    </target>
    <default-operation>merge</default-operation>
    <test-option>set</test-option>
    <config>
      <interfaces xmlns:t="http://ndt-inc.com/ns/ndt-interfaces">
        <interface xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0" operation="create">
          <name>if6</name>
        </interface>
      </interfaces>
    </config>
  </edit-config>
</rpc>
```

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```
    </config>
  </edit-config>
</rpc>
```

Note that the **red** portion is directly copied from file "1.xml".

### 3.4.3 *.ncclient/config/rpc* folder

NcClient implements 'rpc' command. E.g.

```
> rpc f1
```

This command would search for file "f1.xml" in "rpc" folder, and if found, read it and pass the content of this file to YANGDemoAgent for processing. An example of the content:

```
<rpc message-id="101" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get>
    <filter type="subtree">
      <garage></garage>
    </filter>
  </get>
</rpc>
```

### 3.5 *.sshd*

```
ndncsub          SSH NetConf interface module
```

## 4 Windows Installation Notes

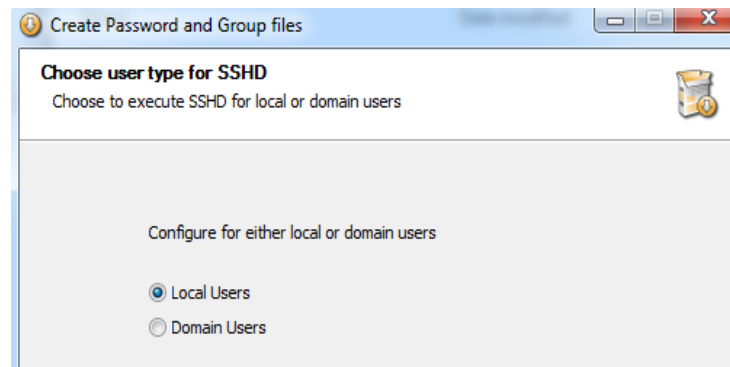
### 4.1 SSH Server

SSH Server is required for NetConf over SSH (rfc6242). YANGDemoAgent setup includes OpenSSH for Windows: a minimal OpenSSH server in the Cygwin package without needing the full Cygwin installation (<http://sshtwindows.sourceforge.net/>).

YANGDemoAgent setup will configure "netconf" subsystem on the SSH server, and enable port 830.

### 4.2 User name

When installing OpenSSH please set configuration of SSHD to "Run as SSHD\_Server" and select "No" for Privilege Separation. Next, select either "Local Users" (recommended) or "**Domain Users**", however please note that on a large domain network it may take a long time for the SSH installation to deal with the large number of domain users.



This selection and your Windows User accounts determine the users that will be added to the "passwd" file (usually C:\Program Files (x86)\OpenSSH\etc\passwd). **Entries in the "passwd" file represent the Users that can be used to connect NcClient, through OpenSSH connection, to the YANGDemoAgent.**

As an example, assume domain name is "COOL" and workstation name is "W7X64".

If "Local Users" is selected, lines in "passwd" file could look like:

```
Dave:unused:1000:513:U-W7X64\Dave,S-1-5-21-3363657122-4092627159-322903561-1000:/home/Dave:/bin/bash
```

The 1st word in the line (Dave) is the User Name that openssh learnt. The "Dave / password" pair is to be used in NcClient's connect. The "Dave / password" represents your actual Windows account login credentials, for either your local Windows name or email based login user, here it is a local user for machine "W7X64".

If "Domain Users" is selected, lines in "passwd" file could look like:

```
Dave:unused:11000:10513:U-COOL\Dave,S-1-5-21-3408015411-1710520510-3648052309-1000:/home/Dave:/bin/bash
```

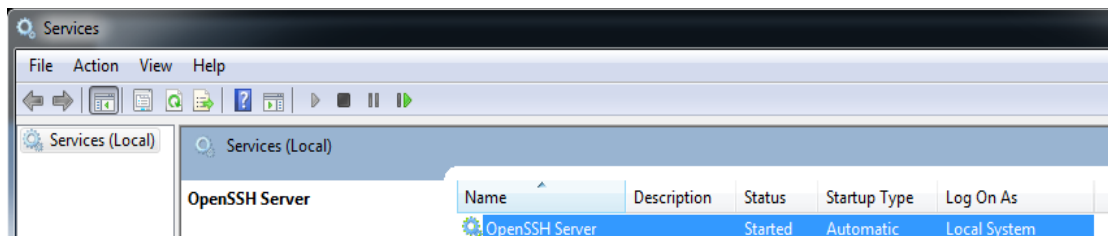
The 1st word in the line (Dave) is the domain User Name that openssh learnt. The "Dave / password" pair is to be used in NcClient's connect. "U-COOL\Dave" represents the actual domain user for the domain "COOL".

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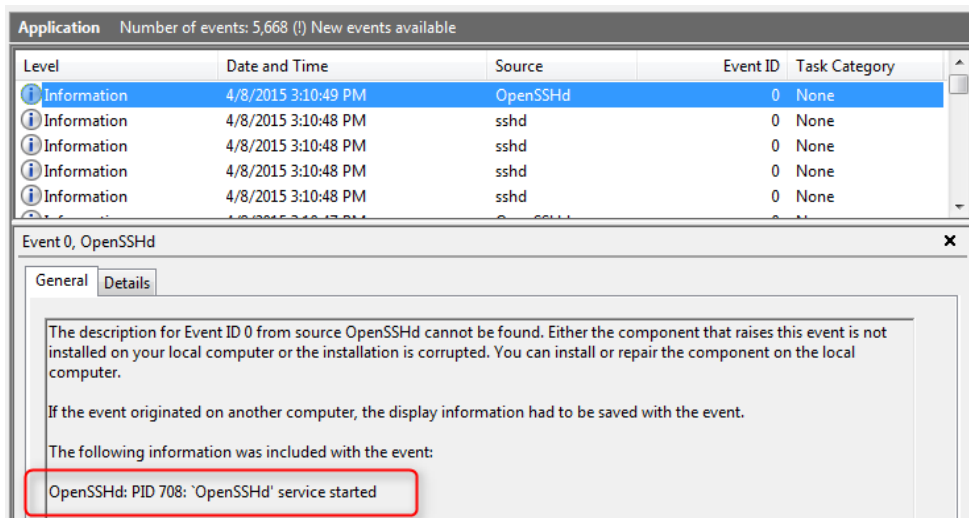
In other words, irrelevant of the selection of "Local Users"/"Domain Users", the username to be used in NcClient's connect is the Windows name without machine/domain prefix and your Windows login password.

### 4.3 OpenSSHd service

OpenSSH server is installed as windows service:



When properly started OpenSSH server creates entries in the event log:



"sshd" entries should look like:

sshd: PID 908: Server listening on 0.0.0.0 port 22.  
sshd: PID 908: Server listening on :: port 22.  
sshd: PID 908: Server listening on 0.0.0.0 port 830.  
sshd: PID 908: Server listening on :: port 830.

Note that OpenSSH server is listening on port 830 for netconf connections.

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## 5 Linux Installation Notes

The Linux version of YANG Demo Agent has been verified on the following 64bit Linux distributions:

- CentOS 7
- Fedora 20
- Fedora 23 - 28
- Debian 8.6
- Ubuntu 16.04
- OpenSUSE 42.1

**Note 1:** Some of these extra notes for Linux may be Fedora 23-28 specific.

**Note 2:** most of the following steps require **root** level privilege.

**Note 3:** the server needs to be run as **root** (or **sudo**) to access privileged ports: (SNMP 161 by default)

1) **chmod +x** the install **.bin** file you downloaded to /home/<your user directory> to make sure it is executable. Execute the **.bin** file to install the demo. If you do this from the same directory as the file, remember to prefix the file name with **./**, since typically root's search path doesn't include the current directory.

2) Make sure **sshd** is installed on your Linux. How to do this varies with the distribution. Then stop it:

```
# systemctl stop sshd
```

3) Add entries for 'ndncsub' to **/etc/ssh/sshd\_config** directly below appropriate lines (commented or not)

```
Port 830
Subsystem netconf /opt/YangServerDemo-x.y/ssh/ndncsub
```

4) Ensure **sshd** starts at startup (it may be disabled by default, depending on distribution)

note: **systemctl** may not be available on all distributions, if not you can likely skip this step)

```
# systemctl enable sshd
```

5) Enable **sshd** to use port 830 (for netconf) - probably not be necessary on most distributions, (Fedora/RedHat yes).

```
# semanage port -a -t ssh_port_t -p tcp 830
```

6) make sure sshd is restarted with new configuration items. How depends on the distribution.

```
# service sshd restart
```

or

```
# /etc/init.d/ssh restart
```

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If all else fails, kill and start '**sshd -D**' manually.

Do a '**netstat -a -t**' to ensure port 830 is open.

7) If firewall is running, open firewall ports for remote access (may not be necessary on all distributions)

- A) Install "Firewall configuration tool" (optional)
- B) Open "Firewall configuration tool" (optional)
- C) add port to firewall exceptions (make it "permanent", if you want it to power up with these)

SNMP	udp	161-162
NETCONF	ssh	tcp 830

Alternatively, you can disable the firewall. This can be done (on fedora) with

```
# systemctl stop firewalld
```

To have it not start again on startup, you need to

```
# systemctl disable firewalld
```

Now you should be ready to run the YANG DEMO Agent and NETConf Client

8) run the yang demo server. From a terminal/console, in the **agent** directory.

```
# demostart
```

9) run the **netconf** demo client. From a terminal/console, in the **ncclient** directory

```
# ncclientstart
```

## 6 YANG Demo Agent Module Compliance

**YANGDemoAgent** implements the standard yang modules:

ietf-inet-types  
ietf-yang-types  
SNMPv2-TC  
ietf-netconf  
ietf-netconf-monitoring  
ietf-netconf-acm  
ietf-writable-running  
ietf-confirmed-commit  
ietf-partial-lock

**ietfInterfaces** data dll implements module:

ietf-interfaces

**Garage** data dll implements proprietary module:

garage (simulation of garage, created from ND-GARAGE-MIB,  
<http://www.ndt-inc.com/SNMP/GarageProject.html>).

**ndtaasnmpp** implements yang modules:

- SNMPv2-MIB
- ietf-snmp

with the following submodules:

ietf-snmp-common  
ietf-snmp-engine  
ietf-snmp-target  
ietf-snmp-notification  
ietf-snmp-proxy  
ietf-snmp-community  
ietf-snmp-usm  
ietf-snmp-vacm



## 7 Windows YANGDemoAgent Command Line Options

YANGDemoAgent [-c configDir] [-s schemaDir] [-d dllDir] [-b bakDir] [-l logDir] [-w] [-a]

<b>configDir</b>	folder with agent configuration files, default is <b>config</b> sub-folder of the folder where YANGDemoAgent is located.
<b>schemaDir</b>	folder with yang modules. Agent searches this folder while processing "get-schema" rpc. Default is <b>schema sub-folder</b> of the folder where YANGDemoAgent is located.
<b>dllDir</b>	folder where data DLLs are located, default is the folder where YANGDemoAgent is located
<b>bakDir</b>	folder where backup files are stored, default is <b>%APPDATA%\NuDesign\YANGDemoAgent\bak</b>
<b>logDir</b>	folder where log files are stored, default is <b>%APPDATA%\NuDesign\YANGDemoAgent\log</b>
<b>-w</b>	create a new log file on each agent start, this is default. File name format is YANGDemoAgent-xxx.log where xxx is encoded date/time in format YYMMDDhhmmss. E.g. YANGDemoAgent-151206191025.log
<b>-a</b>	a single log file named YANGDemoAgent.log is created, log output is appended

**APPDATA** is environment variable, execute "echo %APPDATA%" at the command prompt to see the value:



## 8 Linux ndyangdemo Command Line Options

ndyangdemo [-c configDir] [-s schemaDir] [-b bakDir] [-l logDir] [-w] | [-a]

<b>configDir</b>	folder with agent configuration files, default is <b>config</b> sub-folder of the folder where <b>ndyangdemo</b> is located.
------------------	--

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<b>schemaDir</b>	folder with yang modules. Agent searches this folder while processing "get-schema" rpc. Default is <b>schema sub-folder</b> of the folder where <b>ndyangdemo</b> is located.
<b>bakDir</b>	folder where backup files are stored, default is the <b>bak</b> folder where <b>ndyangdemo</b> is located.
<b>logDir</b>	folder where log files are stored, default is , default is the <b>log</b> folder where <b>ndyangdemo</b> is located.
<b>-w</b>	create a new log file on each agent start, this is default. File name format is <b>ndyangdemo-xxx.log</b> where xxx is encoded date/time in format YYMMDDhhmmss. E.g. <b>ndyangdemo-18090611530.log</b>
<b>-a</b>	a single log file named <b>ndyangdemo.log</b> is created, log output is appended

Note: **ndyangdemo** needs the path to the libraries in **./lib** set. This can be done various ways, but for testing it is sufficient to set **LD\_LIBRARY\_PATH** to the **lib** directory. E.g.

```
export LD_LIBRARY_PATH=./lib
```

if executed from the **agent** directory.

Alternatively, you can invoke **./demostart** from the **agent** directory and this will start **ndyangdemo** with the default parameters and set **LD\_LIBRARY\_PATH** appropriately.

## 9 Demo

To start YANGDemoAgent in Windows double click YANGDemoAgent.exe (Or click "NDT YANG Demo Agent" in programs).

To start YANGDemoAgent in Linux, go to the **agent** directory and invoke **./demostart..**

On startup YANGDemoAgent executes the following steps:

- read settings (./config/agent/ngsettings.xml ), here is the excerpt:

```
<ndt>
  <agents>
    <agent name="cli" dll="ndtaaccli.dll"></agent>
    <agent name="nc" dll="ndtaanetconf.dll" ></agent>
    <agent name="snmp" dll="ndtaasnmp.dll"></agent>
  </agents>
  <datadlls>
    <datadll name="garage" dll="Garage.dll" ></datadll>
    <datadll name="if" dll="ietfInterfaces.dll" ></datadll>
  </datadlls>
```

- read settings on Linux (./config/agent/ndconf.xml), here is the excerpt:

```
<ndt>
  <agents>
    <agent name="cli" dll="libndtaaccli.so.0"></agent>
    <agent name="nc" dll="libndtaanetconf.so.0" ></agent>
    <agent name="snmp" dll="libndtaasnmp.so.0"></agent>
  </agents>
  <datadlls>
    <datadll name="garage" dll="libndGarageMib.so.0" ></datadll>
    <datadll name="if" dll="libietfInterfaces.so.0" ></datadll>
  </datadlls>
```

- load AddOn agents (listed in section **<agents>**)

- load data dlls (listed in section **<datadlls>**, in this example Garage.dll ), initialize and register modules implemented in each dll

- load **startup-cfg.xml** into RUNNING configuration data store

- copy RUNNING to CANDIDATE

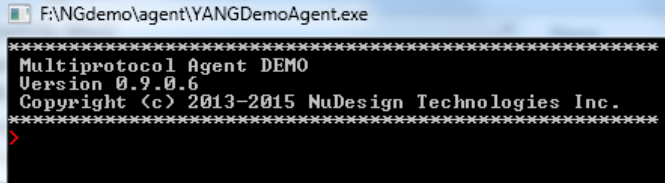
- initialize AddOn agents (at this point running configuration contains parameters required by AA to be initialized properly)

- refresh state data (get initial state of objects that are not part of configuration, e.g. counters)

- record start time

- start AddOn agents

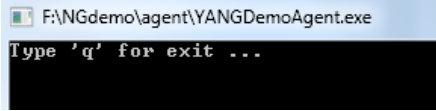
- if **ndtaaccli** is successfully loaded pass control to it:



```
F:\NGdemo\agent\YANGDemoAgent.exe
*****
Multiprotocol Agent DEMO
Version 0.9.0.6
Copyright (c) 2013-2015 NuDesign Technologies Inc.
*****
>
```

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otherwise print



```
F:\NGdemo\agent\YANGDemoAgent.exe
Type 'q' for exit ...
```

In other words, other AddOn agents could be running without ndtacli. YANGDemoAgent creates verbose log files. The name of the log file is "<executable-name>.log", e.g. "YANGDemoAgent.log". Windows Log file is created in subdirectory "log". Linux Log file is created in /usr/local/NuDesign/YANGServerDemo/client/log.

## 9.1 Working with CLI

CLI emulates Junos. CLI is started in operational mode, indicated by prompt "> ". To get a list of available command type "?" (question mark).

```
> ?
Possible completions:
about
configure
datadll
exit
help
quit
session
show
> █
```

Execute "configure" command to enter configuration mode. indicated by [edit] line above prompt, prompt changes to # )

```
> configure[Enter]
Candidate configuration is now locked.
[edit ]
# █
```

In configuration mode user can modify data in "candidate" datastore (which is locked by CLI during execution of "configure" command). Once "candidate" is configured, to apply changes to "running" configuration user must execute "commit" command.

Here is the example how to create row in vehiclesTable:

```
[edit ]
# show garage[Enter] <--- display current config
// config-candidate //
garageObjects
  garageAddress 10 Street
  garageCOLevelRisingThreshold 50
  garageCOLevelFallingThreshold 10
vehiclesEntry
  vehicleIndex 1
  vehicleLicencePlate 123 ABC
  vehicleModel Maserati Quattroporte
vehiclesEntry
  vehicleIndex 2
  vehicleLicencePlate 345 XYZ
  vehicleModel Jaguar F-Type
```

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```

[edit ]
# create garage vehiclesEntry 3[Enter]          <--- create new entry
ok
[edit ]
# show garage[Enter]                            <--- display current config
// config-candidate //
garageObjects
  garageAddress 10 Street
  garageCOLevelRisingThreshold 50
  garageCOLevelFallingThreshold 10
vehiclesEntry
  vehicleIndex 1
  vehicleLicencePlate 123 ABC
  vehicleModel Maserati Quattroporte
vehiclesEntry
  vehicleIndex 2
  vehicleLicencePlate 345 XYZ
  vehicleModel Jaguar F-Type
vehiclesEntry
  vehicleIndex 3                                <--- new row created, note that vehicleLicencePlate
  vehicleLicencePlate 555 QQQ                  <--- and vehicleModel is not created yet
[edit ]
# create garage vehiclesEntry 3 vehicleLicencePlate "555 QQQ"[Enter] <--- create vehicleLicencePlate
ok
[edit ]
# create garage vehiclesEntry 3 vehicleModel "Audi TT"[Enter]        <--- create vehicleModel
ok
[edit ]
# show garage[Enter]                            <--- display current config
// config-candidate //
garageObjects
  garageAddress 10 Street
  garageCOLevelRisingThreshold 50
  garageCOLevelFallingThreshold 10
vehiclesEntry
  vehicleIndex 1
  vehicleLicencePlate 123 ABC
  vehicleModel Maserati Quattroporte
vehiclesEntry
  vehicleIndex 2
  vehicleLicencePlate 345 XYZ
  vehicleModel Jaguar F-Type
vehiclesEntry
  vehicleIndex 3
  vehicleLicencePlate 555 QQQ
  vehicleModel Audi TT
[edit ]
# commit[Enter]                                <--- commit
ok
[edit ]
# show running[Enter]                          <--- show running configuration
// config-running //
garage
  garageObjects
    garageAddress 10 Street
    garageCOLevelRisingThreshold 50
    garageCOLevelFallingThreshold 10
  vehiclesEntry
    vehicleIndex 1
    vehicleLicencePlate 123 ABC
    vehicleModel Maserati Quattroporte
  vehiclesEntry
    vehicleIndex 2
    vehicleLicencePlate 345 XYZ

```

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```

vehicleModel Jaguar F-Type
vehiclesEntry
  vehicleIndex 3
  vehicleLicencePlate 555 QQQ
  vehicleModel Audi TT[edit ]
#

```

## 9.2 Working with NcClient

To start NcClient in Windows double click NcClient.exe (Or click "NcClient" in programs).

To start **ncclient** in Linux, go to the **ncclient** directory and type **ncclientstart** in a terminal window.

NcClient is command line NetConf client. Command line handling is the same as in CLI AA. Difference is that NcClient does not have configuration mode. Rather, commands are implementation of NetConf rpc commands defined in `ietf-netconf` Yang module. A few commands (e.g. `edit-config`) expect xml as argument/payload, and it would be impractical to provide such input in command line. So the argument for such commands is the name of the file that contains part of the xml string required.

NcClient 'connect' command establishes communication with YANGDemoAgent. If connect succeeds, NcClient sends "hello" message (shown in light blue below), and read "hello" from server:

```

> connect 127.0.0.1 admin[Enter]
Password: *****
Fingerprint: A0 E0 6A E9 E1 29 85 3E 77 37 AB 20 97 88 03 88 83 5B 78 ED
Authentication methods: publickey,password,keyboard-interactive
Sending NETCONF client <hello>
<?xml version="1.0" encoding="UTF-8"?>
<hello>
<capabilities>
<capability>
urn:ietf:params:netconf:base:1.0
</capability>
<capability>
urn:ietf:params:netconf:base:1.1
</capability>
</capabilities>
</hello>
]]>]]>
Reading NETCONF server <hello>
  capabilities
    capability urn:ietf:params:netconf:base:1.0
...
>

```

At this point, session is created, and user can issue netconf commands.

Here is the example how to create row in vehiclesTable:

```

> get-config candidate xpath //garage[Enter] <--- get candidate configuration
data
  garage
...
  vehiclesEntry
    vehicleIndex 1
    vehicleLicencePlate 123 ABC

```

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```

    vehicleModel Maserati Quattroporte
vehiclesEntry
  vehicleIndex 2
  vehicleLicencePlate 345 XYZ
  vehicleModel Jaguar F-Type
vehiclesEntry
  vehicleIndex 3
  vehicleLicencePlate 555 QQQ
  vehicleModel Audi TT
> lock candidate[Enter]          <--- lock configuration
ok
> list edit-config c1[Enter]     <--- display content of file to be used as argument
<default-operation>merge</default-operation>
<test-option>set</test-option>
<config>
  <t:garage xmlns:t="urn:ietf:params:xml:ns:yang:smiv2:ND-GARAGE-MIB" >
    <t:vehiclesEntry xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0" nc:ope
ration="create" >
      <t:vehicleIndex>4</t:vehicleIndex>
      <t:vehicleLicencePlate>777 SWE</t:vehicleLicencePlate>
      <t:vehicleModel>Koenigsegg One:1</t:vehicleModel>
    </t:vehiclesEntry>
  </t:garage>
</config>
> edit-config candidate c1[Enter]  <--- execute edit-config rpc
ok
> lock running[Enter]            <--- lock configuration
ok
> commit[Enter]                 <--- commit changes to running configuraton
ok
> unlock running[Enter]         <--- unlock configuration
ok
> unlock candidate[Enter]       <--- unlock configuration
ok
> get xpath //garage[Enter]     <--- get running configuration
data
  garage
...
  vehiclesEntry
    vehicleIndex 1
    vehicleLicencePlate 123 ABC
    vehicleModel Maserati Quattroporte
    vehicleStatus active
  vehiclesEntry
    vehicleIndex 2
    vehicleLicencePlate 345 XYZ
    vehicleModel Jaguar F-Type
    vehicleStatus active
  vehiclesEntry
    vehicleIndex 3
    vehicleModel Audi TT
    vehicleLicencePlate 555 QQQ
    vehicleStatus active
  vehiclesEntry          <--- new entry
    vehicleIndex 4
    vehicleLicencePlate 777 SWE
    vehicleModel Koenigsegg One:1
    vehicleStatus active
>

```

### 9.2.1 Notifications in NcClient

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Check notification streams supported:

```
> get xpath //stream[Enter]
rpc-reply
data
  stream
    name NETCONF
    description NETCONF stream
    replaySupport true
    replayLogCreationTime 2015-04-06T21:10:58Z
  stream
    name SNMP
    description SNMP stream
    replaySupport false
```

Subscribe for notifications:

```
> create-subscription[Enter]
rpc-reply
ok
>
```

Later (garage dll demo sends coLevelFallingAlarm and coLevelRisingAlarm periodically):

```
notification
  eventTime 2015-04-06T21:20:22Z
  coLevelFallingAlarm
    object-1
      garageCOLevel 9
```

The subscription can be terminated by using <close-session>

```
> close-session[Enter]
rpc-reply
ok
>
```

or <kill-session> (from different client instance)

When subscribing for notifications with replay, user must specify {startTime} or {startTime, stopTime}.

If only startTime is specified, agent will replay all available notifications in the log since the startTime. After finishing the replay agent sends "replayComplete" notification. Agent will continue to send notifications to the client after that.

```
> create-subscription startTime 2015-04-06T00:00:00Z[Enter]
>
rpc-reply
ok

notification
  eventTime 2015-04-06T23:16:04Z
  netconf-session-start
    username cli
```

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```

session-id 1

notification
eventTime 2015-04-06T23:16:04Z
netconf-session-start
username snmp
session-id 2

notification
eventTime 2015-04-06T23:16:10Z
netconf-session-start
username borislav
session-id 3

notification
eventTime 2015-04-06T23:16:25Z
coLevelRisingAlarm
object-1
garageCOLevel 51

notification
eventTime 2015-04-06T23:16:41Z
replayComplete      <<<--- after this notification, session becomes regular notif subscriber
...

notification
eventTime 2015-04-06T23:20:00Z
coLevelFallingAlarm
object-1
garageCOLevel 9

```

There are two scenarios when stopTime is specified:

1) If the stopTime is before current time, agent will replay notifications up to the stopTime and cancel the subscription.

```

> create-subscription startTime 2015-04-15T00:00:00Z stopTime 2015-04-06T23:17:00Z[Enter]
>
rpc-reply
ok

notification
eventTime 2015-04-06T23:16:04Z
netconf-session-start
username cli
session-id 1

notification
eventTime 2015-04-06T23:16:04Z
netconf-session-start
username snmp
session-id 2

notification
eventTime 2015-04-06T23:16:10Z
netconf-session-start
username borislav
session-id 3

notification

```

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```

eventTime 2015-04-06T23:16:25Z
coLevelRisingAlarm
  object-1
    garageCOLevel 51

notification
  eventTime 2015-04-06T23:21:07Z
  replayComplete

notification
  eventTime 2015-04-06T23:21:07Z
  notificationComplete <<<--- after this notification agent will stop sending new notifications

```

2) If the stopTime is in the future, agent will replay all available notifications in the log since the startTime and send "replayComplete" notification. Agent will continue to send new notifications until the stopTime, at which point agent will send "notificationComplete" notification.

```

> create-subscription startTime 2015-04-06T23:23:40Z stopTime 2015-04-06T23:30:00Z[Enter]
>
rpc-reply
  ok

notification
  eventTime 2015-04-06T23:23:42Z
  coLevelRisingAlarm
    object-1
      garageCOLevel 51

notification
  eventTime 2015-04-06T23:24:16Z
  replayComplete <<<--- after this notification agent will continue to send notifications ...

...

notification
  eventTime 2015-04-06T23:24:33Z
  coLevelFallingAlarm
    object-1
      garageCOLevel 9

...

notification
  eventTime 2015-04-06T23:30:00Z <<<--- ... until stopTime
  notificationComplete

```

Error may be reported depending on the validity of the subscription request. E.g. if the startTime is in the future:

```

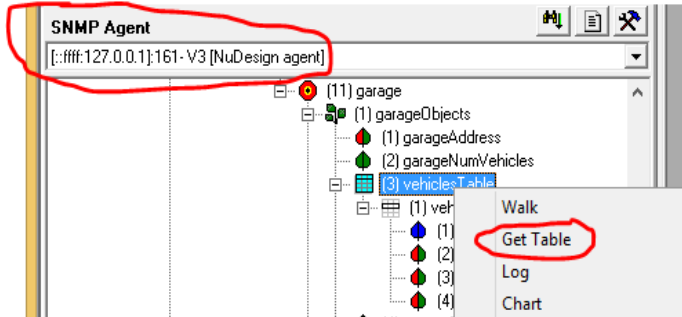
> create-subscription startTime 2016-04-24T10:00:00Z[Enter]
>
rpc-reply
  rpc-error
    error-type protocol
    error-tag bad-element
    error-severity error
    error-app-tag invalid-data
    error-path /rpc/create-subscription/startTime

```

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### 9.3 Working with SNMP

Start Visual MIBBrowser, load ND-GARAGE-MIB (NDGarageV2.mib), select DEMO agent as target (127.0.0.1), right click "vehicleTable" and select "Get Table" from context menu:



Result is:

INDEX	vehicleLicencePlate	vehicleModel	vehicleStatus
.1	123 ABC	Maserati Quattroporte	active (1)
.2	345 XYZ	Jaguar F-Type	active (1)
.3	555 QQQ	Audi TT	active (1)
.4	777 SWE	Koenigsegg One:1	active (1)

Now create a new row:

Instance	Syntax	Value	Set Value
vehicleStatus.5	RowStatus	noSuchInstance	createAndGo (4)
vehicleLicencePlate.5	DisplayString	noSuchInstance	222 ZXC
vehicleModel.5	DisplayString	noSuchInstance	Ford Mustang GT500

Send "set" request by clicking "Execute" button (circled in red). Refresh getTable window:

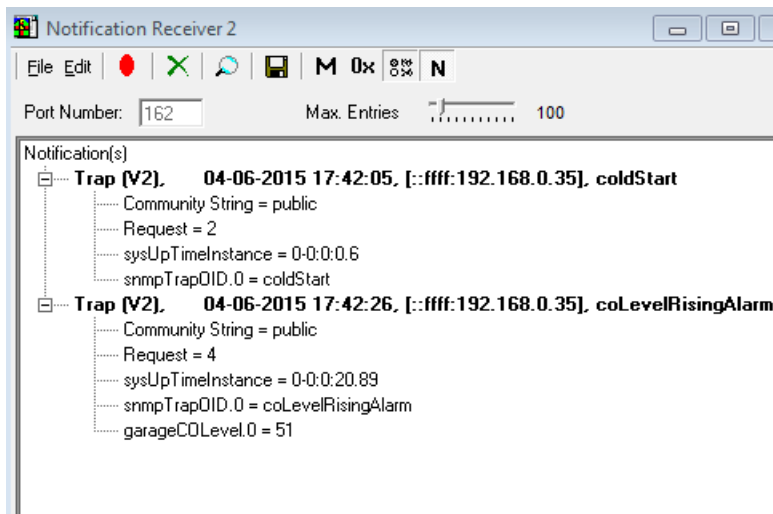
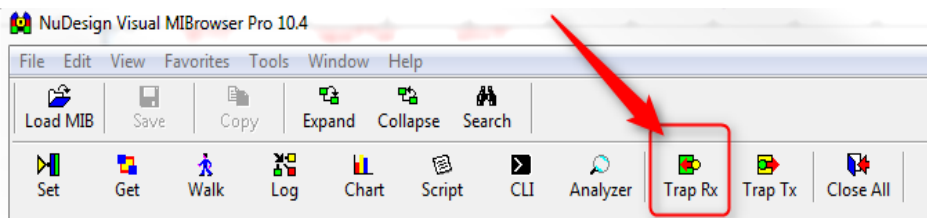
INDEX	vehicleLicencePlate	vehicleModel	vehicleStatus
.1	123 ABC	Maserati Quattroporte	active (1)
.2	345 XYZ	Jaguar F-Type	active (1)
.3	555 QQQ	Audi TT	active (1)
.4	777 SWE	Koenigsegg One:1	active (1)
.5	222 ZXC	Ford Mustang GT500	active (1)

datadll unload

#### 9.3.1 Notifications in MIBBrowser

Open trap receiver:

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## 9.4 All together

Retrieve configurations from NcClient:

```

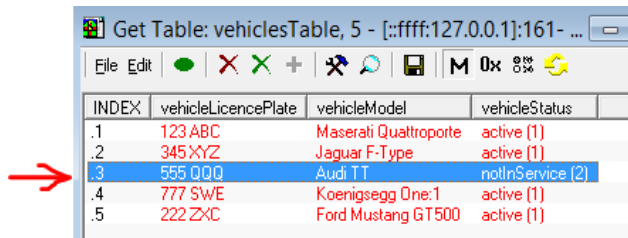
> get-config candidate xpath //vehiclesEntry[Enter] <--- get candidate configuration
data
  garage
    vehiclesEntry
      vehicleIndex 1
      vehicleLicencePlate 123 ABC
      vehicleModel Maserati Quattroporte
    vehiclesEntry
      vehicleIndex 2
      vehicleLicencePlate 345 XYZ
      vehicleModel Jaguar F-Type
    vehiclesEntry
      vehicleIndex 3
      vehicleLicencePlate 555 QQQ
      vehicleModel Audi TT
    vehiclesEntry
      vehicleIndex 4
      vehicleLicencePlate 777 SWE
      vehicleModel Koenigsegg One:1
    vehiclesEntry
      vehicleIndex 5
      vehicleLicencePlate 222 ZXC
      vehicleModel Ford Mustang GT500
> get-config running xpath //vehiclesEntry[Enter] <--- get running configuration
data
  garage
    vehiclesEntry
      vehicleIndex 1
      vehicleLicencePlate 123 ABC
      vehicleModel Maserati Quattroporte
    vehiclesEntry
      vehicleIndex 2
      vehicleLicencePlate 345 XYZ
      vehicleModel Jaguar F-Type
    vehiclesEntry
      vehicleIndex 3
      vehicleLicencePlate 555 QQQ
      vehicleModel Audi TT
    vehiclesEntry
      vehicleIndex 4
      vehicleLicencePlate 777 SWE
      vehicleModel Koenigsegg One:1
    vehiclesEntry
      vehicleIndex 5
      vehicleLicencePlate 222 ZXC
      vehicleModel Ford Mustang GT500
>

```

Running and candidate are the same. The reason is that SNMP AA synchronizes running and candidate after each successful set request.

Set one row in table to notInService:

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INDEX	vehicleLicencePlate	vehicleModel	vehicleStatus
.1	123 ABC	Maserati Quattroporte	active (1)
.2	345 XYZ	Jaguar F-Type	active (1)
.3	555 000	Audi TT	notInService (2)
.4	777 SWE	Koenigsegg One:1	active (1)
.5	222 ZXC	Ford Mustang GT500	active (1)

Only 'active' rows are part of configuration. Verify in NcClient:

```
> get-config running xpath //vehiclesEntry[Enter] <--- get running configuration
data
  garage
    vehiclesEntry
      vehicleIndex 1
      vehicleLicencePlate 123 ABC
      vehicleModel Maserati Quattroporte
    vehiclesEntry
      vehicleIndex 2
      vehicleLicencePlate 345 XYZ
      vehicleModel Jaguar F-Type <--- #3 is deleted
    vehiclesEntry
      vehicleIndex 4
      vehicleLicencePlate 777 SWE
      vehicleModel Koenigsegg One:1
    vehiclesEntry
      vehicleIndex 5
      vehicleLicencePlate 222 ZXC
      vehicleModel Ford Mustang GT500
>
```

Delete row using NcClient:

```
> list edit-config d1[Enter] <--- content of d1.xml
<default-operation>merge</default-operation>
<test-option>set</test-option>
<config>
  <t:garage xmlns:t="urn:ietf:params:xml:ns:yang:smiv2:ND-GARAGE-MIB" >
    <t:vehiclesEntry xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0" nc:ope
ration="delete" >
      <t:vehicleIndex>4</t:vehicleIndex>
    </t:vehiclesEntry>
  </t:garage>
</config>

> lock candidate[Enter] <--- lock configuration
ok
> edit-config candidate d1[Enter] <--- execute edit-config rpc (arg = d1.xml)
ok
> lock running[Enter] <--- lock configuration
ok
> commit[Enter] <--- commit changes to running configuraton
ok
> unlock running[Enter] <--- unlock configuration
ok
> unlock candidate[Enter] <--- unlock configuration
ok
```

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```
> get-config running xpath //vehiclesEntry[Enter] <--- get running configuration
data
  garage
    vehiclesEntry
      vehicleIndex 1
      vehicleLicencePlate 123 ABC
      vehicleModel Maserati Quattroporte
    vehiclesEntry
      vehicleIndex 2
      vehicleLicencePlate 345 XYZ
      vehicleModel Jaguar F-Type <--- #4 is deleted
    vehiclesEntry
      vehicleIndex 5
      vehicleLicencePlate 222 ZXC
      vehicleModel Ford Mustang GT500
>
```

Check with MIBrowser:

INDEX	vehicleLicencePlate	vehicleModel	vehicleStatus
.1	123 ABC	Maserati Quattroporte	active (1)
.2	345 XYZ	Jaguar F-Type	active (1)
.5	222 ZXC	Ford Mustang GT500	active (1)

## 10 CLI

This section describes commands implemented by CLI AddOn Agent (ndtacli.dll).

Type ? to see a list of available commands:

```
> ?
Possible completions:
about
configure
datadll
exit
help
quit
session
show
> █
```

### 10.1 Command completion

To complete a partial command enter <tab> immediately after a command prefix, e.g.

show

```
> s[Tab]
Ambiguous command: s
Possible completions:
session
show
> s█
```

In the example below, there are 2 commands that start with prefix "s". List of possible completions is printed along with the error message "Ambiguous command". New command line is extended to the first 'non-ambiguous' letter (in this case new cmd line is not extended as "s" is already the longest common prefix for these 2 commands) and cursor positioned immediately after it.

Type next letter and [Tab] :

```
> conf[Tab]
```

and command will be completed:

```
> configure █
```

If there is no command that starts with prefix:

```
> cond[Tab]
Couldn't complete, no match found
> cond█
```

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## 10.2 Commands and parameters

### 10.2.1 ? or <prefix>?

List all commands or just commands that start with <prefix>. E.g.

```
> s?
Possible completions:
  session
  show
> c
```

### 10.2.2 about

*about*

Show YANGDemoAgent information:

```
> about[Enter]
*****
* Multiprotocol Agent DEMO          *
* Version x.x.x.x                  *
* Copyright © 2013-2018 NuDesign Technologies Inc. *
*****
>
```

### 10.2.3 configure

*configure*

Enter configuration mode (indicated by [edit] line above prompt, prompt changes to #)

```
> configure[Enter]
[edit ]
#
```

See "Configuration Mode" section for details.

### 10.2.4 datadll [load|unload] <name>

*datadll [load | unload] <name>*

Load or unload data dll. Argument <name> is the name attribute for datadll element in "ngsettings.xml":

```
<datadlls>
  <datadll name="garage" dll="Garage.dll" ></datadll>
```

Argument <name> is also displayed in the output of "show datadll":

```
> show datadll[Enter]
data
  dll
    name garage
    path Garage.dll
    loaded true
>
> datadll unload garage[Enter]
ok
```

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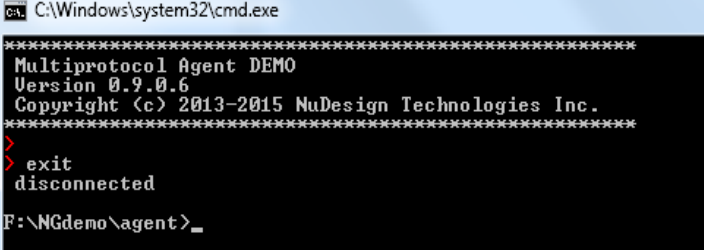
```
> datadll load garage[Enter]
ok
>
```

NOTE: Generates "netconf-capability-change" notification.

### 10.2.5 exit

*exit*

Exit the YANGDemoAgent.



```
C:\Windows\system32\cmd.exe
*****
Multiprotocol Agent DEMO
Version 0.9.0.6
Copyright (c) 2013-2015 NuDesign Technologies Inc.
*****
>
> exit
disconnected
F:\NGdemo\agent>_
```

In configuration mode, "exit" command moves the current position one level up. If at the root of configuration tree, exit configuration mode.

```
[edit ] <--- /
# edit garage vehiclesEntry 1[Enter]
[edit garage vehiclesEntry "1" ] <--- /garage/vehiclesEntry[vehiclesIndex=1]
# exit[Enter]
[edit garage ] <--- /garage
# exit[Enter]
[edit ] <--- /
# exit[Enter]
> <--- op mode
```

### 10.2.6 help

*help <cmdname>*

Print help for command specified in argument.

```
> help configure[Enter]
Enter configuration mode
> █
```

### 10.2.7 quit

*quit*

exit the YANGDemoAgent.

### 10.2.8 session

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## *session*

Display CLI session info

```
> session[Enter]
SESSION: user:cli, id:1, status:connected
```

## **10.2.9 show**

*show [agents | datadll | history | running]*

### **show agents**

Display AddOn agents status

```
> show agents[Enter]
'cli', ndtaaccli.dll OK
'nc', ndtaanetconf.dll OK
'snmp', ndtaasntp.dll OK
> █
```

### **show datadll**

Display list of configured data dlls with 'loaded' status

```
> show datadll[Enter]
data
  dll
    name garage
    path Garage.dll
    loaded true
```

### **show history**

Display command line history.

```
> show history[Enter]
0: about
1: show running
> █
```

### **show running**

Display running configuration

```
> show running[Enter]
// config-running //
garage
  garageObjects
  garageAddress 10 street
...
```

### 10.3 Configuration mode

Configuration mode commands operate on configuration data. To enter configuration mode execute `configure` command. Commands available in configuration mode at any position are:

```
[edit ]
# ?
Possible completions:
commit
create
delete
edit
exit
help
load
quit
run
save
set
show
top
up
[edit ]
# █
```

Commands operate on config data available at the current position, see `edit`, `up`, `top`, `exit`. On entering configuration mode current position is set to root. Excerpts from YANGDemoAgent configuration to be used in examples:

```
<config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <garage xmlns="urn:ietf:params:xml:ns:yang:smiv2:ND-GARAGE-MIB">
    ...
    <snmp xmlns="urn:ietf:params:xml:ns:yang:ietf-snmp">
      ...
```

Possible arguments for "set" command at root level are:

```
[edit ]
# set ?
Possible completions:
<[Enter]>          Execute this command
garage
mib-2.snmp
snmp
system
[edit ]
# set █
```

Change position to "garage"

```
[edit ]
# edit garage
[edit garage ]
# █
```

Possible args for "set" command at this level are:

```
[edit garage ]
# set ?
```

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```
Possible completions:
<[Enter]>      Execute this command
garageObjects
vehiclesEntry
[edit garage ]
# set █
```

### 10.3.1 commit

*commit*

Applies changes in candidate configuration to running.

```
> commit[Enter]
ok
> █
```

### 10.3.2 create

*create arg1 [arg2] [...]*

Create configuration data (corresponds to edit-config, operation="create").

```
[edit garage]
# create vehiclesEntry 5[Enter]
ok
[edit garage ]
# show[Enter]
// config-candidate //
...
    vehiclesEntry
        vehicleIndex 1
...
    vehiclesEntry
        vehicleIndex 2
...
    vehiclesEntry
        vehicleIndex 5
[edit garage ]
# █
```

### 10.3.3 delete

*delete arg1 [arg2] [...]*

Delete configuration data.

```
[edit garage ]
# delete vehiclesEntry 2[Enter]
ok
[edit garage ]
# show[Enter]
// config-candidate //
...
    vehiclesEntry
        vehicleIndex 1
...
    vehiclesEntry
        vehicleIndex 5
```

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```
...
[edit garage ]
# █
```

### 10.3.4 edit

```
edit arg1 [arg2] [...]
```

[edit] line shows current position in configuration hierarchy. To navigate configuration hierarchy use **edit**, **up** and **top**.

```
[edit ] <--- /
# edit garage vehiclesEntry 1[Enter]
[edit garage vehiclesEntry "1" ] <--- /garage/vehiclesEntry[vehiclesIndex=1]
# show[Enter]
// config-candidate //
  vehicleIndex 1
  vehicleLicencePlate 123 ABC
  vehicleModel Maserati Quattroporte
[edit garage vehiclesEntry "1" ] <--- /garage/vehiclesEntry[vehiclesIndex=1]
# up[Enter]
[edit garage ] <--- /garage
# show[Enter]
// config-candidate //
  garageObjects
  garageAddress 10 Street
...
[edit garage ] <--- /garage
# up[Enter]
[edit ] <--- /
# edit garage vehiclesEntry 1[Enter]
[edit garage vehiclesEntry "1" ] <--- /garage/vehiclesEntry[vehiclesIndex=1]
# top[Enter]
[edit ] <--- /
# █
```

### 10.3.5 exit

```
exit [discard]
```

Exit configuration mode if the current position is configuration root. Otherwise move one level up (the same as 'up' command)

```
[edit ]
# exit[Enter]
> █
```

If there are uncommitted changes made to candidate configuration

```
[edit ]
# exit[Enter]
There are uncommitted changes.
Use 'commit' to commit the changes, or 'exit discard' to discard them.
[edit ]
# exit discard[Enter]
> █
```

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`exit discard` executed at any level is the same as `quit`.

### 10.3.6 load

`load <file> candidate|running`

Load configuration from <file> into candidate or running configuration.

```
[edit ]
# load newcfg.xml candidate[Enter]
ok
[edit ]
#
```

### 10.3.7 quit

`quit`

Exit configuration mode discarding changes (if any), the same as 'exit discard'.

```
[edit ]
# exit[Enter]
There are uncommitted changes.
Use 'commit' to commit the changes, or 'exit discard' to discard them.
[edit ]
# quit[Enter]
>
```

### 10.3.8 run

`run arg1 [arg2] [...]`

Execute system command.

```
[edit ]
# run ping 192.168.0.1[Enter]
Executing 'ping 192.168.0.1'
Press Ctrl-C to interrupt

Pinging 192.168.0.1 with 32 bytes of data:
Reply from 192.168.0.1: bytes=32 time<1ms TTL=64
...
Approximate round trip times in milliseconds:
  Minimum = 0ms, Maximum = 0ms, Average = 0ms
[edit ]
#
```

### 10.3.9 save

`save candidate|running <file>`

Save running or candidate configuration to file.

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```
[edit ]
# save candidate test[Enter]
ok
[edit ]
# █
```

### 10.3.10 set

*set arg1 [arg2] [...]*

Modify configuration data (corresponds to edit - config, operation="replace").

```
[edit ]
# show garage garage0objects garageAddress[Enter]
// config-candidate //
  garageAddress 10 Street                                <-- current address
[edit ]
# set garage garage0objects garageAddress "123 avenue rd."[Enter] <-- change address
ok
[edit ]
# show garage garage0objects garageAddress[Enter]
// config-candidate //
  garageAddress 123 avenue rd.                          <-- new address
[edit ]
# █
```

### 10.3.11 show

*show [running] [arg1] [arg2] [...]*

Display configuration. By default displays candidate configuration data.

```
[edit ]
# show[Enter]
// config-candidate //
  snmp
    engine
      enabled true
      listen
      udp
  ...
```

To display running configurator:

```
[edit ]
# show running[Enter]
// config-running //
  snmp
    engine
      enabled true
      listen
      udp
  ...
```

Argument can be any node that is direct child of the current position.

```
# show ?
Possible completions:
<[Enter]>          Execute this command
```

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```
garage
mib-2.snmp
history
running
snmp
system
[edit ]
# show running ?
Possible completions:
<[Enter]>          Execute this command
garage
mib-2.snmp
snmp
system
[edit ]
# show running
```

```
[edit ]
# show garage[Enter]
// config-candidate //
   garageObjects
   garageAddress Avenue road
[edit ]
#
```

### 10.3.12 top

*top*

Change current position to configuration root

See *edit*

### 10.3.13 up

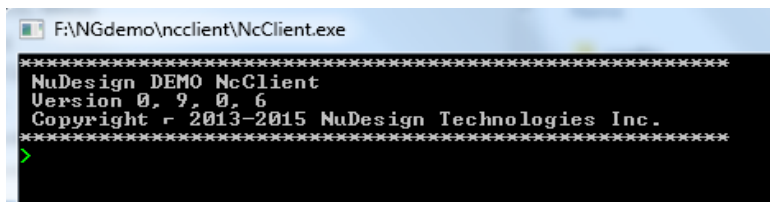
*up*

Change current position one level up

See *edit*

## 11 NcClient.exe - NetConf client

NcClient is command line NetConf client. To start double click NcClient.exe. If ok, console will be created and prompt shown:



```

F:\NGdemo\ncclient\NcClient.exe
*****
NuDesign DEMO NcClient
Version 0, 9, 0, 6
Copyright © 2013-2015 NuDesign Technologies Inc.
*****
>

```

On Linux, open a console and go to to the **ncclient** directory and type “**./ncclientstart**”.

The UI is similar to the CLI's. Type ? (question mark) to see the list of available commands:

```

> ?
Possible completions:
about
cls
connect
exit
help
list
quit
script
show
>

```

### 11.1 Commands and parameters

#### 11.1.1 ? or <prefix>?

List all commands or just commands that start with <prefix>. E.g.

```

> c?
Possible completions:
configure
connect
> c

```

#### 11.1.2 about

*about*

Show NcClient information:

```

> about [Enter]

```

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```

*****
NuDesign DEMO NcClient
Version x, x, x, x
Copyright © 2013-2018 NuDesign Technologies Inc.
*****
> █

```

### 11.1.3 *cls*

Clears the console.?

### 11.1.4 *connect*

```
connect <host> [username]
```

Connect NcClient to NetConf agent (YANGDemoAgent). Host is mandatory argument. User name can be specified as the second argument, or at the "User:" prompt. Password must always be provided at "Password:" prompt.

On Linux, use a valid Linux user and password.

Below is an example of an unsuccessful connection:

```

> connect 192.168.0.21[Enter]
User: admin
Password: *****
Failed to connect to 192.168.0.21!
> █

```

If the **connect** succeeds, NcClient sends "hello" message (shown in light blue below), and read "hello" from server:

```

> connect 127.0.0.1 admin[Enter]
Password: *****
Fingerprint: A0 E0 6A E9 E1 29 85 3E 77 37 AB 20 97 88 03 88 83 5B 78 ED
Authentication methods: publickey,password,keyboard-interactive
Sending NETCONF client <hello>
<?xml version="1.0" encoding="UTF-8"?>
<hello>
<capabilities>
<capability>
urn:ietf:params:netconf:base:1.0
</capability>
<capability>
urn:ietf:params:netconf:base:1.1
</capability>
</capabilities>
</hello>
]]>]]>
Reading NETCONF server <hello>
capabilities
  capability urn:ietf:params:netconf:base:1.0
...
> █

```

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At this point various 'netconf' commands are available:

```
> ?
Possible completions:
about
cancel-commit
close-session
cls
commit
connect
copy-config
create-subscription
delete-config
discard-changes
disconnect
edit-config
exit
get
get-config
get-schema
help
kill-session
list
lock
partial-lock
partial-unlock
quit
rpc
show
unlock
validate
> █
```

### 11.1.5 close-session

*close-session*

Sends request for graceful termination of a NETCONF session.

```
> close-session[Enter]
<?xml version="1.0" encoding="UTF-8" ?><rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="1">
  <close-session xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" />
</rpc>
ok
> █
```

### 11.1.6 create-subscription

*create-subscription [startTime YYYY-MM-DDThh:mm:ssZ]*

This operation initiates an event notification subscription that will send asynchronous event notifications to the NcClient until the subscription terminates.

```
> create-subscription[Enter]
ok
> █
```

Later:

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```
>
notification
  eventTime 2015-04-03T20:56:19Z
  netconf-capability-change
  changed-by
    username cli
    session-id 1
  added-capability urn:ietf:params:xml:ns:yang:smiv2:ND-GARAGE-MIB?module=ND-GARAGE-
MIB&revision=2004-07-09
```

Subscribe for notifications with replay:

```
> create-subscription startTime 2015-04-01T00:00:00Z[Enter]
notification
  eventTime 2015-04-06T21:10:59Z
  netconf-session-start
  username cli
  session-id 1

notification
  eventTime 2015-04-06T21:10:59Z
  netconf-session-start
  username snmp
  session-id 2

notification
  eventTime 2015-04-06T21:11:17Z
  netconf-session-start
  username borislav
  session-id 3

notification
  eventTime 2015-04-06T21:11:19Z
  coLevelRisingAlarm
  object-1
    garageCOLevel 51

rpc-reply
  ok
> █
```

### 11.1.7 commit

*commit*

The commit operation instructs the device to implement the configuration data contained in the candidate configuration, i.e candidate configuration is copied to running configuration.

```
> commit[Enter]
ok
> █
```

### 11.1.8 copy-config

*copy-config <source> <target>*

*copy-config candidate|running|startup|<url> candidate|running|startup|<url>*

Supported value for url is file URI scheme. Extension "xml" is appended to url.

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```
> copy-config candidate abc[Enter]
source: candidate
target: file:///abc.xml
ok
> |
```

### 11.1.9 delete-config

*delete-config startup|<url>*

Supported value for url is file URI scheme.

```
> delete-config startup[Enter]
target: startup
ok
> |
```

### 11.1.10 discard-changes

*discard-changes*

Revert the candidate configuration to the current running configuration

```
> discard-changes[Enter]
ok
> |
```

### 11.1.11 disconnect

*disconnect*

Disconnect NcClient from YANGDemoAgent, 'netconf' command are removed.

### 11.1.12 edit-config

*edit-config candidate|running <file-name>*

The <edit-config> operation loads all or part of a specified configuration to the specified target configuration datastore. This command reads file specified as the argument (extension xml is assumed) from folder NGdemo/config/edit-config, and creates **edit-config** rpc request to be executed by YANGDemoAgent. E.g. file might contain:

```
<default-operation>merge</default-operation>
<test-option>set</test-option>
<config>
  <t:garage xmlns:t="urn:ietf:params:xml:ns:yang:smiv2:ND-GARAGE-MIB" >
    <t:vehiclesEntry xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0" nc:operation="create" >
      <t:vehicleIndex>4</t:vehicleIndex>
      <t:vehicleLicencePlate>777 SWE</t:vehicleLicencePlate>
      <t:vehicleModel>Koenigsegg One:1</t:vehicleModel>
    </t:vehiclesEntry>
  </t:garage>
</config>
```

This command will add rpc wrapper around it:

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```
<rpc message-id="3" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <target>
      <candidate />
    </target>
    CONTENT OF THE FILE IS INSERTED HERE
  </edit-config>
</rpc>
```

before passing it to YANGDemoAgent for processing.

```
> get-config candidate xpath //vehiclesEntry[Enter] <--- retrieve current config
data
  vehiclesEntry
    vehicleIndex 1
    vehicleLicencePlate 123 ABC
    vehicleModel Maserati Quattroporte
...
> list edit-config 2[Enter] <--- check content of 2.xml
<default-operation>merge</default-operation>
<test-option>set</test-option>
<config>
  <t:garage xmlns:t="urn:ietf:params:xml:ns:yang:smiv2:ND-GARAGE-MIB" >
    <t:vehiclesEntry xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0" nc:ope
ration="create" >
      <t:vehicleIndex>4</t:vehicleIndex>
      <t:vehicleLicencePlate>777 SWE</t:vehicleLicencePlate>
      <t:vehicleModel>Koenigsegg One:1</t:vehicleModel>
    </t:vehiclesEntry>
  </t:garage>
</config>
> edit-config candidate 2[Enter] <--- send edit-config rpc
ok
> get-config candidate xpath //vehiclesEntry[Enter] <--- retrieve config
data
  vehiclesEntry
    vehicleIndex 1
    vehicleLicencePlate 123 ABC
    vehicleModel Maserati Quattroporte
...
vehiclesEntry <--- new entry created
  vehicleIndex 4
  vehicleLicencePlate 777 SWE
  vehicleModel Koenigsegg One:1
> █
```

### 11.1.13 exit

`exit`

Shutdown the NcClient.

### 11.1.14 get

`get [path|subtree|xpath <filter>]`

Retrieve running configuration and state data from NetConf server. Executing get without parameters retrieves

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all data. YANGDemoAgent supports subtree and xpath filtering. <filter> argument depends on argument preceding it.

```
> get xpath //sessions[Enter]
data
  sessions
    session
      session-id 1
  ...
```

```
> get subtree "<netconf-state><sessions><session /></sessions></netconf-state>"[Enter]
data
  netconf-state
    sessions
      session
        session-id 1
  ...
```

Specifying subtree filter in command line is cumbersome. "path" is simpler way to specify subtree filter. E.g. "/netconf-state/sessions/session" is internally translated in "<netconf-state><sessions><session /></sessions></netconf-state>"

```
> get path /netconf-state/sessions/session[Enter]
data
  netconf-state
    sessions
      session
        session-id 1
  ...
```

### 11.1.15 get-config

```
get-config candidate|running|startup [path|subtree|xpath <filter>]
```

Retrieve all or part of a specified configuration datastore (specified as the 1st argument). If filter is omitted retrieves all configuration data.

Processing of filter is the same as in **get**.

```
> get-config candidate
data
  garage
    garageObjects
      garageAddress 10 Street
      garageCOLevelRisingThreshold 50
      garageCOLevelFallingThreshold 10
    vehiclesEntry
      vehicleIndex 1
  ...
```

### 11.1.16 get-schema

```
get-schema identifier [<version> [<format>]]
```

Retrieve "schema" from the NetConf server:

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```
> get-schema ietf-netconf[Enter]
data module ietf-netconf {

    // the namespace for NETCONF XML definitions is unchanged
    // from RFC 4741 which this document replaces

    namespace "urn:ietf:params:xml:ns:netconf:base:1.0";

    prefix nc;

    import ietf-inet-types {
        prefix inet;
    }

    organization
        "IETF NETCONF (Network Configuration) Working Group";
    ...
}
```

<version> and <format> are optional.

<version> is specified as YYYY-MM-DD, e.g. 2011-03-08

The only supported format is "ncm:yang".

### 11.1.17 help

*help <cmdname>*

Print help for command specified in argument.

```
> help disconnect[Enter]
Disconnect from netconf server/agent
> █
```

### 11.1.18 kill-session

*kill-session session-id*

Force the termination of a NETCONF session. "snmp" session can not be terminated this way.

```
> kill-session 3[Enter]
ok
> █
```

### 11.1.19 list

*list edit-config|rpc <file-name>*

Print content of file from 'edit-config' or 'rpc' folder'. If file name is missing print list of files in corresponding folder.

```
> list edit-config[Enter]
1.xml
2.xml
3.xml
> █
```

If the file name is missing print list of files in corresponding folder.

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```
> list edit-config 2[Enter]
<default-operation>merge</default-operation>
<test-option>set</test-option>
<config>
  <t:garage xmlns:t="urn:ietf:params:xml:ns:yang:smiv2:ND-GARAGE-MIB" >
    <t:vehiclesEntry xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0" nc:operation="create" >
      <t:vehicleIndex>4</t:vehicleIndex>
      <t:vehicleLicencePlate>777 SWE</t:vehicleLicencePlate>
      <t:vehicleModel>Koenigsegg One:1</t:vehicleModel>
    </t:vehiclesEntry>
  </t:garage>
</config>
> █
```

### 11.1.20 lock

*lock running|candidate|startup*

Lock the entire configuration datastore system of a device.

```
> lock candidate[Enter]
ok
> █
```

### 11.1.21 partial-lock

*partial-lock <xpath>*

Perform a partial lock on a portion of the datastore system of a device, given by **<xpath>**.

```
> partial-lock netconf-state[Enter]
lock-id 100
locked-node /netconf-state
> █
```

### 11.1.22 partial-unlock

*partial-unlock* <unlock-id>

Perform an unlock on a portion of the datastore system of a device, given by <lock-id>.

```

> partial-unlock 100[Enter]
>
rpc-reply
ok
>

```

### 11.1.23 quit

*quit*

Shutdown the NcClient.

### 11.1.24 rpc

*rpc* <file-name>

This command reads the file <file-name> from NGdemo/config/rpc folder. <file-name> can be specified without extension, in that case ".xml" is appended. File should contain valid netconf rpc request. An example of the content:

```

<rpc message-id="101" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
<get>
  <filter type="subtree">
    <garage>
      </garage>
    </filter>
  </get>
</rpc>

```

**message-id** is replaced by CLI before passing request to YANGDemoAgent for processing.

Assuming content of f1.xml is shown above:

```

> rpc f1[Enter]
garage
  garageObjects
    garageAddress 10 Street
    garageNumVehicles 2
...

```

If file does not exist:

```

> rpc f2[Enter]
Failed to open file config\rpc\f2.xml
>

```

To display content of the file:

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```
> rpc show f0[Enter]
<rpc message-id="101" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
<get>
<filter type="subtree">
</filter>
</get>
> █
```

### 11.1.25 show

*show history*

Display command line history.

```
> show history[Enter]
0: connect
1: lock candidate
2: unlock candidate
```

### 11.1.26 unlock

*unlock running|candidate|startup*

Lock the entire configuration datastore system of a device.

```
> unlock candidate[Enter]
ok
> █
```

### 11.1.27 validate

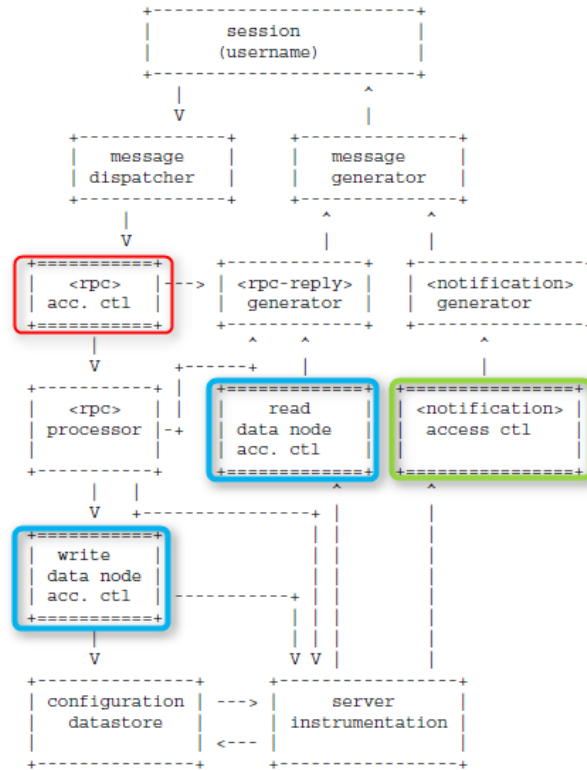
*validate running|candidate|startup|<url>|config <filename>*

Validate the contents of the specified configuration.

```
> validate startup[Enter]
source: startup ok
> delete-config startup[Enter]
target: startup
ok
> validate startup[Enter]
source: startup rpc-error
error-type application
error-tag internal-error
error-severity error
error-app-tag general-error
error-message Data store is deleted
> █
```

## 12 NACM - Access Control

Access Control is specified in RFC 6536: *Network Configuration Protocol (NETCONF) Access Control Model*. Here is the diagram from RFC with access control modules highlighted:



**NOTE:** YANGDemoAgent is shipped with "nacm" disabled in startup configuration. To enable access control user should modify "nacm" section and restart the agent. Also, user should add his/hers user-name to each group, examples in this document are for user "test".

**NOTE 2:** YANGDemoAgent creates backup of startup-cfg.xml before overwriting it. See section "YANGDemoAgent Command Line Options" for the backup location.

Access control configuration is located under **nacm** element in **startup-cfg.xml**. Here is the excerpt:

```
<nacm xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-acm">
  <enable-nacm>true</enable-nacm>          nacm is enabled
  <read-default>permit</read-default>      if no rule is found allow read and notify
  <write-default>deny</write-default>      if no rule is found deny write operations
  <exec-default>permit</exec-default>      if no rule is found allow execution of rpc
  <groups>
    <group>...</group>
    ... more groups ...
  </groups>
  <rule-list>
    <rule>...</rule>
    ... more rules ...
  </rule-list>
</nacm>
```

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## 12.1 Incoming RPC Message Validation

The following nacm configuration allows execution of all rpcs except "validate" rpc for user "test"

```
<nacm xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-acm">
  <enable-nacm>true</enable-nacm>
  <exec-default>permit</exec-default>           default is permit
  <groups>
    <group>
      <name>admin</name>
      <user-name>test</user-name>              replace "test" with your login
    </group>
  </groups>
  <rule-list>
    <name>rule1</name>
    <group>*</group>
    <rule>
      <name>rule1-2</name>
      <module-name>*</module-name>
      <rpc-name>validate</rpc-name>
      <access-operations>*</access-operations>
      <action>deny</action>
    </rule>
  </rule-list>
</nacm>
```

"get" is allowed, "validate" is denied:

```
> get [Enter]
rpc-reply
  data
    snmp
    engine
  ...
> validate candidate [Enter]
rpc-reply
  rpc-error
    error-type application
    error-tag access-denied
    error-severity error
    error-app-tag no-access
    error-path /nc:ietf-netconf/nc:validate
    error-message NC: access denied
> |
```

## 12.2 Outgoing <notification> Authorization

Garage dll in YangDEMOAgent generates coLevelFallingAlarm and coLevelRisingAlarm notifications in random intervals.

The following nacm configuration allows all outgoing notifications.

```
<nacm xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-acm">
  <enable-nacm>true</enable-nacm>
  <read-default>permit</read-default>         default is permit
```

In NcClient:

```
> create-subscription [Enter]
>
```

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```

rpc-reply
  ok

notification
  eventTime 2015-12-11T20:06:37Z
  coLevelRisingAlarm          <<<--- "rising"
    object-1
      garageCOLevel 51
    id 4

notification
  eventTime 2015-12-11T20:07:28Z
  coLevelFallingAlarm        <<<--- "falling"
    object-1
      garageCOLevel 9
    id 5
...

```

The following addition to nacm configuration will deny "coLevelRisingAlarm" notification defined in "ND-GARAGE-MIB" yang module to be sent to session with user "test".

```

<nacm xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-acm">
...
  <groups>
    <group>
      <name>admin</name>
      <user-name>test</user-name>
    </group>
  </groups>
  <rule-list>
    <name>rule1</name>
    <group>*</group>
    <rule>
      <name>rule1-2</name>
      <module-name>ND-GARAGE-MIB</module-name>
      <notification-name>coLevelRisingAlarm</notification-name>
      <access-operations>*</access-operations>
      <action>deny</action>
    </rule>
  </rule-list>
</nacm>

```

In NcClient, note that "rising" notifications are missing:

```

> create-subscription[Enter]
>
rpc-reply
  ok

notification
  eventTime 2015-12-11T20:12:51Z
  coLevelFallingAlarm        <<<--- "falling"
    object-1
      garageCOLevel 9
    id 5

notification
  eventTime 2015-12-11T20:14:13Z
  coLevelFallingAlarm        <<<--- "falling"
    object-1
      garageCOLevel 9

```

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```
id 7
...
```

### 12.3 Data Node Access Validation

The following nacm configuration allows read access to all objects in datastore.

```
<nacm xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-acm">
  <enable-nacm>true</enable-nacm>
  <read-default>permit</read-default> default is permit
```

In NcClient:

```
> get [Enter]
data
  snmp
    engine
      enabled true
...
```

Actually "permit" applies to all objects defined without nacm extension "default-deny-all". Definition of "nacm" container in **module ietf-netconf-acm** is:

```
container nacm {
  nacm:default-deny-all;
```

hence, "nacm" objects will be missing from the reply to "get" rpc. Add the following rule to be able to read "nacm" objects:

```
<rule>
  <name>rule1-4</name>
  <module-name>*</module-name>
  <path>//nacm</path>
  <access-operations>read</access-operations>
  <action>permit</action>
</rule>
```

When this rule is present (providing "user-name" is a member of the "group" specified in the "rule-list" to which this "rule" belongs):

```
> get [Enter]
data
  snmp
    engine
      enabled true
...
  nacm
    enable-nacm true
    read-default permit
...
```

Here is the example how to exclude object from the "read" view,

```
<rule>
```

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```

<name>rule1-1</name>
<module-name>ND-GARAGE-MIB</module-name>
<path>//garageAddress</path>
<access-operations>read</access-operations>
<action>deny</action>
</rule>

```

Without the rule above:

```

> get xpath //garageObjects[Enter]
data
  garageObjects
    garageAddress 10 Street
    garageNumVehicles 2
    garageCOLevel 22
    garageCOLevelRisingThreshold 50
    garageCOLevelFallingThreshold 10
>

```

After adding the rule (note that garageAddress is missing):

```

> get xpath //garageObjects[Enter]
data
  garageObjects
    garageNumVehicles 2
    garageCOLevel 22
    garageCOLevelRisingThreshold 50
    garageCOLevelFallingThreshold 10

```

By default write operation is denied:

```

<nacm xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-acm">
  <enable-nacm>true</enable-nacm>
  <write-default>deny</write-default>
  <default-is-deny/>
</nacm>

```

Using c1.xml as an example (see 6.1.1 edit-config):

```

<config>
  <t:garage xmlns:t="urn:ietf:params:xml:ns:yang:smiv2:ND-GARAGE-MIB" >
    <t:garageObjects>
      <t:garageAddress>123 eglinton</t:garageAddress>
    </t:garageObjects>
  </t:garage>
</config>

```

In NcClient:

```

> edit-config candidate c1[Enter]
rpc-error
  error-type application
  error-tag access-denied
  error-severity error
  error-app-tag no-access
  error-path /nc:config-candidate/nc:config/nd-garage:garage
  error-message NC: access denied

```

After adding the following rule:

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```

<rule>
  <name>rule1-1</name>
  <module-name>ND-GARAGE-MIB</module-name>
  <path>/garageAddress</path>
  <access-operations>read create update delete</access-operations>
  <action>permit</action>
</rule>

```

edit-config should succeed.

```

> edit-config candidate c1[Enter]
ok

```

## 12.4 Debugging Access Control

Access control configuration can be quite complicated and sometimes hard to find the problem when unexpected result occurs. YangDEMOAgent outputs debug messages while processing access control to the log file. Such lines start with:

**nacmr** - rpc access control

**nacmn** - notification access control

**nacmd** - data access control

The 1st line of access control processing contains session id, user name and rpc/notification or object name. E.g. notification "netconf-session-start" for session id =1, user = "test",

```
nacmn [1:test] netconf-session-start
```

One or more log lines following the 1st line are related to processing that rpc/notification or object name. The last one contains either "permit" or "deny". E.g.

```
nacmn 11 permit
```

Here is the example of multi-line output while processing edit-config:

```

nacmd [2:test] /config-candidate/config/garage/garageObjects/garageAddress
nacmd 6.1, rule=rule1-1, module-match=ND-GARAGE-MIB
nacmd 6.2 A match=/config-candidate/config/garage/garageObjects/garageAddress
nacmd 6.3.2 create
nacmd 7 permit

```

Example of denied rpc:

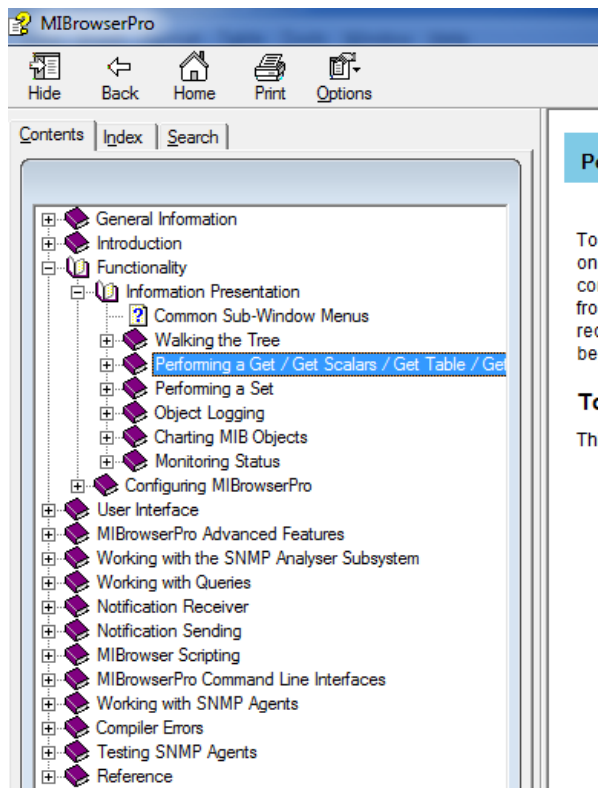
```

nacmr [2:test] /ietf-netconf/validate
nacmr 8 deny

```

### 13 SNMP

Use MIBrowser to access YANGDemoAgent. Please check MIBrowser help for more information.



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## ***14 About NuDesign***

NuDesign Technologies, Inc., headquartered in Toronto, ON, Canada, specializes in providing NetConf, SNMP, CLI and web agent & manager development applications, tools, libraries and consulting services to developers and networking OEMs worldwide. The benefits of deploying NuDesign's management software technologies are reliable, low risk, well integrated and quick-to-market solutions, supporting management operations over IPv4 / IPv6 networks in carrier, campus and enterprise settings.

Our focus is on industry standard management protocols such as NetConf, SNMP and protocols using HTTP transport. Our customers are Original Equipment Manufacturers, System Integrators, Service Providers and End Users worldwide.

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## 15 Appendix

### 15.1 'ND-GARAGE-MIB' Yang module

```

/*
This Yang module was created using NuDesign Technologies' Visual MIBuilder (Ver 5.2).
MIB File : NDGarageV2.mib
Module : ND-GARAGE-MIB
*/

module ND-GARAGE-MIB {

    namespace "urn:ietf:params:xml:ns:yang:smiv2:ND-GARAGE-MIB";
    prefix "nd-garage";

    import ietf-yang-types          { prefix "yang"; }
    import ietf-yang-smiv2         { prefix "smiv2"; }
    import SNMPv2-TC               { prefix "snmpv2-tc"; }

    organization
        "NuDesign Technologies, Inc.";
    contact
        "NuDesign Technologies, Inc.
        Web site: www.ndt-inc.com
        Email: contact@ndt-inc.com";
    description
        "The MIB module for managing car garage.";

    revision 2004-07-09 {
        description
            "New version released that is to be used across all NuDesign Products. sh";
    }
    revision 2002-10-11 {
        description
            "Added objects garageCOLevel, garageCOLevelRisingThreshold and
            garageCOLevelFallingThreshold and notifications
            coLevelRisingAlarm and coLevelFallingAlarm.
            Updated notif-groups and compliance. bl";
    }
    revision 2002-01-17 {
        description
            "Modified the access of vehicleModel to ReadCreate. sh";
    }
    revision 2001-03-21 {
        description
            "Added notifications and conformance statements. bl";
    }
    revision 2000-05-01 {
        description
            "Initial version. bl";
    }

    container garage {
        config false;

        container garageObjects {

            smiv2:oid "1.3.6.1.4.1.4761.99.11.1";
            leaf garageAddress {
                type snmpv2-tc:DisplayString {
                    length "0..32";
                }
            }
        }
    }
}

```

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```

        description
            "Garage address. For example: 10 St, SomePlace.";
        smiv2:max-access "read-write";
        smiv2:oid "1.3.6.1.4.1.4761.99.11.1.1";
    }
    leaf garageNumVehicles {
        type int32;
        description
            "Number of vehicles currently parked in the garage.";
        smiv2:max-access "read-only";
        smiv2:oid "1.3.6.1.4.1.4761.99.11.1.2";
    }
    leaf garageCOLevel {
        type int32;
        description
            "CO toxicity level in garage (airborne concentration level expressed in
            parts per million or PPM).";
        smiv2:max-access "read-only";
        smiv2:oid "1.3.6.1.4.1.4761.99.11.1.4";
    }
    leaf garageCOLevelRisingThreshold {
        type int32;
        description
            "Level of CO toxicity level in garage (in parts per million or PPM)
            considered dangerous for humans. 400 PPM causes serious headache
            after 1-2 hours of exposure. This level is life threatening after 3 hours.
            When the current sampled value is greater than or equal to
            this threshold, and the value at the last sampling interval
            was less than this threshold, a single event (coLevelRisingAlarm)
            will be generated.
            After a rising event is generated, another such event will not be
            generated until the sampled value falls below this threshold and
            reaches the garageCOLevelFallingThreshold.";
        smiv2:max-access "read-write";
        smiv2:oid "1.3.6.1.4.1.4761.99.11.1.5";
    }
    leaf garageCOLevelFallingThreshold {
        type int32;
        description
            "Level of CO toxicity level in garage (in parts per million or PPM)
            considered harmless for humans. 35 PPM is maximum exposure allowed by
            OSHA in the workplace over an eight hour period.
            When the current sampled value is less than or equal to this threshold,
            and the value at the last sampling interval was greater than this threshold,
            a single event (coLevelFallingAlarm) will be generated.
            After a falling event is generated, another such event will not be
            generated until the sampled value rises above this threshold and
            reaches the garageCOLevelRisingThreshold.";
        smiv2:max-access "read-write";
        smiv2:oid "1.3.6.1.4.1.4761.99.11.1.6";
    }
}
/*
container vehiclesTable {
    description
        "Table of vehicles parked in the garage.";
    smiv2:oid "1.3.6.1.4.1.4761.99.11.1.3";
*/
list vehiclesEntry {
    key "vehicleIndex";
    description
        "Row in the vehiclesTable.";

    smiv2:oid "1.3.6.1.4.1.4761.99.11.1.3.1";
}

```

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```

leaf vehicleIndex {
  type int32;
  description
    "Index into vehiclesTable.";
  smiv2:max-access "not-accessible";
  smiv2:oid "1.3.6.1.4.1.4761.99.11.1.3.1.1";
}
leaf vehicleLicencePlate {
  type snmpv2-tc:DisplayString {
    length "6..7";
  }
  description
    "License plate of the vehicle, for example 123XYZ or ABCD987.";
  smiv2:max-access "read-create";
  smiv2:oid "1.3.6.1.4.1.4761.99.11.1.3.1.2";
}
leaf vehicleModel {
  type snmpv2-tc:DisplayString;
  description
    "Make and model of the vehicle; e.g 'NuDesign speedmaster'.
    NuDesign does not manufacture vehicles (yet). This is just
    for demonstration purpose.";
  smiv2:max-access "read-create";
  smiv2:oid "1.3.6.1.4.1.4761.99.11.1.3.1.3";
}
leaf vehicleStatus {
  type snmpv2-tc:RowStatus;
  description
    "Status of this row.";
  smiv2:max-access "read-create";
  smiv2:oid "1.3.6.1.4.1.4761.99.11.1.3.1.4";
}
}
}
/*
*/
}

notification notPaidAlarm {
  description
    "The SNMP trap that is generated when the vehicle leaves garage
    but did not pay the bill.";

  smiv2:oid "1.3.6.1.4.1.4761.99.11.2.1";

  container object-1 {
    leaf vehicleIndex {
      type leafref {
        path "/nd-garage-mib:ND-GARAGE-MIB/nd-garage-mib:vehiclesTable" +
            "/nd-garage-mib:vehiclesEntry/nd-garage-mib:vehicleIndex";
      }
    }
    leaf vehicleLicencePlate {
      type leafref {
        path "/nd-garage-mib:ND-GARAGE-MIB/nd-garage-mib:vehiclesTable" +
            "/nd-garage-mib:vehiclesEntry/nd-garage-mib:vehicleLicencePlate";
      }
    }
  }
}

notification coLevelRisingAlarm {
  description
    "The SNMP trap that is generated when CO toxicity level in garage

```

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```

        crosses its rising threshold (garageCOLevelRisingThreshold).";
smiv2:oid "1.3.6.1.4.1.4761.99.11.2.2";
container object-1 {
    leaf garageCOLevel {
        type leafref {
            path "/nd-garage-mib:ND-GARAGE-MIB/nd-garage-mib:garageObjects/nd-garage-
mib:garageCOLevel";
        }
    }
}
notification coLevelFallingAlarm {
    description
        "The SNMP trap that is generated when CO toxicity level in garage
        crosses its falling threshold (garageCOLevelFallingThreshold).";
    smiv2:oid "1.3.6.1.4.1.4761.99.11.2.3";
    container object-1 {
        leaf garageCOLevel {
            type leafref {
                path "/nd-garage-mib:ND-GARAGE-MIB/nd-garage-mib:garageObjects/nd-garage-
mib:garageCOLevel";
            }
        }
    }
}
smiv2:alias "nuDesignTech" {
    smiv2:oid "1.3.6.1.4.1.4761";
}
smiv2:alias "ndtExperimental" {
    smiv2:oid "1.3.6.1.4.1.4761.99";
}
smiv2:alias "garage" {
    smiv2:oid "1.3.6.1.4.1.4761.99.11";
}
smiv2:alias "garageObjects" {
    smiv2:oid "1.3.6.1.4.1.4761.99.11.1";
}
smiv2:alias "garageEvents" {
    smiv2:oid "1.3.6.1.4.1.4761.99.11.2";
}
smiv2:alias "garageConformance" {
    smiv2:oid "1.3.6.1.4.1.4761.99.11.3";
}
smiv2:alias "garageCompliances" {
    smiv2:oid "1.3.6.1.4.1.4761.99.11.3.1";
}
smiv2:alias "garageGroups" {
    smiv2:oid "1.3.6.1.4.1.4761.99.11.3.2";
}
}

```

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## 15.2 'ND-GARAGE-MIB' MIB module

```

-- *****
-- *
-- * Copyright (c) 2000-2017 NuDesign Technologies, Inc. All Rights Reserved.
-- *
-- * Module Name: ND-GARAGE-MIB
-- *
-- * Description: Defines objects for managing garage for motor vehicles
-- *
-- *****

ND-GARAGE-MIB DEFINITIONS ::= BEGIN

IMPORTS
    NOTIFICATION-TYPE, OBJECT-TYPE, MODULE-IDENTITY,
    enterprises, Integer32
        FROM SNMPv2-SMI
    NOTIFICATION-GROUP, OBJECT-GROUP, MODULE-COMPLIANCE
        FROM SNMPv2-CONF
    RowStatus, DisplayString
        FROM SNMPv2-TC;

garage MODULE-IDENTITY
    LAST-UPDATED "201303140000Z"
    ORGANIZATION
        "NuDesign Technologies, Inc."
    CONTACT-INFO
        "NuDesign Technologies, Inc.
        Web site: www.ndt-inc.com
        Email: contact@ndt-inc.com"
    DESCRIPTION
        "The MIB module for managing car garage."

    REVISION "201303140000Z"
    DESCRIPTION
        "Administrative changes. dp"

    REVISION "200407091226Z"
    DESCRIPTION
        "New version released that is to be used across all NuDesign Products. sh"

    REVISION "200210110900Z"
    DESCRIPTION
        "Added objects garageCOLevel, garageCOLevelRisingThreshold and
        garageCOLevelFallingThreshold and notifications
        coLevelRisingAlarm and coLevelFallingAlarm.
        Updated notif-groups and compliance. bl"

    REVISION "200201171512Z"
    DESCRIPTION
        "Modified the access of vehicleModel to ReadCreate. sh"

    REVISION "200103210000Z"
    DESCRIPTION
        "Addedd notifications and conformance statements. bl"

    REVISION "200005010000Z"
    DESCRIPTION
        "Initial version. bl"
 ::= { ndtExperimental 11 }

nuDesignTech      OBJECT IDENTIFIER ::= { enterprises 4761 }
ndtExperimental  OBJECT IDENTIFIER ::= { nuDesignTech 99 }
garageObjects     OBJECT IDENTIFIER ::= { garage 1 }

```

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```

garageEvents      OBJECT IDENTIFIER ::= { garage 2 }
garageConformance OBJECT IDENTIFIER ::= { garage 3 }

-- Conformance Information

garageCompliances OBJECT IDENTIFIER ::= { garageConformance 1 }
garageGroups      OBJECT IDENTIFIER ::= { garageConformance 2 }

garageAddress OBJECT-TYPE
  SYNTAX      DisplayString (SIZE(0..32))
  MAX-ACCESS  read-write
  STATUS      current
  DESCRIPTION
    "Garage address. For example: 10 St, SomePlace."
    ::= { garageObjects 1 }

garageNumVehicles OBJECT-TYPE
  SYNTAX      Integer32
  MAX-ACCESS  read-only
  STATUS      current
  DESCRIPTION
    "Number of vehicles currently parked in the garage."
    ::= { garageObjects 2 }

vehiclesTable OBJECT-TYPE
  SYNTAX SEQUENCE OF VehiclesEntry
  MAX-ACCESS not-accessible
  STATUS      current
  DESCRIPTION
    "Table of vehicles parked in the garage."
    ::= { garageObjects 3 }

vehiclesEntry OBJECT-TYPE
  SYNTAX      VehiclesEntry
  MAX-ACCESS  not-accessible
  STATUS      current
  DESCRIPTION
    "Row in the vehiclesTable."
  INDEX { vehicleIndex }
  ::= { vehiclesTable 1 }

VehiclesEntry ::= SEQUENCE {
  vehicleIndex
    Integer32,
  vehicleLicencePlate
    DisplayString,
  vehicleModel
    DisplayString,
  vehicleStatus
    RowStatus
}

vehicleIndex OBJECT-TYPE
  SYNTAX      Integer32
  MAX-ACCESS  not-accessible
  STATUS      current
  DESCRIPTION
    "Index into vehiclesTable."
    ::= { vehiclesEntry 1 }

vehicleLicencePlate OBJECT-TYPE
  SYNTAX      DisplayString (SIZE(6..7))
  MAX-ACCESS  read-create
  STATUS      current
  DESCRIPTION

```

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```

    "Licence plate of the vehicle, for example 123XYZ or ABCD987."
    ::= { vehiclesEntry 2 }

vehicleModel OBJECT-TYPE
    SYNTAX      DisplayString
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Make and model of the vehicle; e.g 'NuDesign speedmaster'.
        NuDesign does not manufacture vehicles (yet). This is just
        for demonstration purpose."
    ::= { vehiclesEntry 3 }

vehicleStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Status of this row."
    ::= { vehiclesEntry 4 }

garageCOLevel OBJECT-TYPE
    SYNTAX      Integer32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "CO toxicity level in garage (airborne concentration level expressed in
        parts per million or PPM)."
    ::= { garageObjects 4 }

garageCOLevelRisingThreshold OBJECT-TYPE
    SYNTAX      Integer32
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "Level of CO toxicity level in garage (in parts per million or PPM)
        considered dangerous for humans. 400 PPM causes serious headache
        after 1-2 hours of exposure. This level is life threatening after 3 hours.
        When the current sampled value is greater than or equal to
        this threshold, and the value at the last sampling interval
        was less than this threshold, a single event (coLevelRisingAlarm)
        will be generated.
        After a rising event is generated, another such event will not be
        generated until the sampled value falls below this threshold and
        reaches the garageCOLevelFallingThreshold."
    ::= { garageObjects 5 }

garageCOLevelFallingThreshold OBJECT-TYPE
    SYNTAX      Integer32
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "Level of CO toxicity level in garage (in parts per million or PPM)
        considered harmless for humans. 35 PPM is maximum exposure allowed by
        OSHA in the workplace over an eight hour period.
        When the current sampled value is less than or equal to this threshold,
        and the value at the last sampling interval was greater than this threshold,
        a single event (coLevelFallingAlarm) will be generated.
        After a falling event is generated, another such event will not be
        generated until the sampled value rises above this threshold and
        reaches the garageCOLevelRisingThreshold."
    ::= { garageObjects 6 }

-- Events

```

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```

notPaidAlarm NOTIFICATION-TYPE
  OBJECTS { vehicleLicencePlate }
  STATUS current
  DESCRIPTION
    "The SNMP trap that is generated when the vehicle leaves garage
    but did not pay the bill."
  ::= { garageEvents 1 }

coLevelRisingAlarm NOTIFICATION-TYPE
  OBJECTS { garageCOLevel }
  STATUS current
  DESCRIPTION
    "The SNMP trap that is generated when CO toxicity level in garage
    crosses its rising threshold (garageCOLevelRisingThreshold)."
  ::= { garageEvents 2 }

coLevelFallingAlarm NOTIFICATION-TYPE
  OBJECTS { garageCOLevel }
  STATUS current
  DESCRIPTION
    "The SNMP trap that is generated when CO toxicity level in garage
    crosses its falling threshold (garageCOLevelFallingThreshold)."
  ::= { garageEvents 3 }

-- Compliance statements

garageCompliance MODULE-COMPLIANCE
  STATUS current
  DESCRIPTION
    "The compliance statement for agents which
    implement the ND-GARAGE-MIB. Note that garageNotifGroup2 is
    unconditionally optional for compliance to this MIB module."
  MODULE
    MANDATORY-GROUPS { garageBasicGroup,
                       garageNotifGroup1 }
  ::= { garageCompliances 1 }

-- Units of compliance

garageBasicGroup OBJECT-GROUP
  OBJECTS { garageAddress,
            garageNumVehicles,
            vehicleLicencePlate,
            vehicleModel,
            vehicleStatus,
            garageCOLevel,
            garageCOLevelRisingThreshold,
            garageCOLevelFallingThreshold }
  STATUS current
  DESCRIPTION
    "A collection of objects providing the info for the garage."
  ::= { garageGroups 1 }

garageNotifGroup1 NOTIFICATION-GROUP
  NOTIFICATIONS { coLevelRisingAlarm,
                 coLevelFallingAlarm }
  STATUS current
  DESCRIPTION
    "The threshold notifications."
  ::= { garageGroups 2 }

garageNotifGroup2 NOTIFICATION-GROUP
  NOTIFICATIONS { notPaidAlarm }
  STATUS current
  DESCRIPTION

```

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```
    "The not-paid notification."  
    ::= { garageGroups 3 }  
END
```

```
-- This MIB was created using NuDesign Technology's Visual MIBuilder (Ver 4.4).
```